

## Vertical Transmission of Nematodes: Emphasis on *Uncinaria lucasi* in Northern Fur Seals and *Strongyloides westeri* in Equids

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**ABSTRACT:** A review of vertical transmission of nematodes is presented. Emphasis is on the life cycles of the hookworm, *Uncinaria lucasi* Stiles, 1901, in northern fur seals (*Callorhinus ursinus* Linn.) and the intestinal threadworm, *Strongyloides westeri* Ihle, 1917, in equids. A tabular summary is given for species of nematodes with reported prenatal/transmammary transmission.

**KEY WORDS:** review, vertical transmission, nematodes, *Uncinaria lucasi*, *Strongyloides westeri*, transmammary transmission, northern fur seals, equids.

Most of this discourse will be on the life cycles of the hookworm (*Uncinaria lucasi*) in northern fur seals (*Callorhinus ursinus*) and the intestinal threadworm (*Strongyloides westeri*) in equids (*Equus caballus*). The author investigated the transmission aspect of the life cycle of these 2 species of parasites. Additionally, other nematode species reported to have vertical transmission are summarized.

### Periods and Places of Investigation

Research by the author on *U. lucasi* included 5 trips to Alaska. Three trips, in 1960, 1961, and 1962, were as a graduate student working with O. Wilford Olsen, his major professor, and totalling about 13 months (Lyons and Olsen, 1960, 1962a, b; Lyons, 1963; Olsen and Lyons, 1962, 1965). Two other trips to Alaska involved working with Mark Keyes in 1977 and 1978, totalling about 6 wk (Lyons and Keyes, 1978; Lyons et al., 1978, 1980). Also, there was cooperative research with Mike Bigg in Canada (Bigg and Lyons, 1981; Lyons and Bigg, 1983) and Mark Keyes in Seattle (Lyons and Keyes, 1984). For the life cycle of *S. westeri*, research was conducted in central Kentucky, mostly over the 10-yr period 1963–1973 (Lyons et al., 1969, 1973, 1977).

### *Uncinaria lucasi*

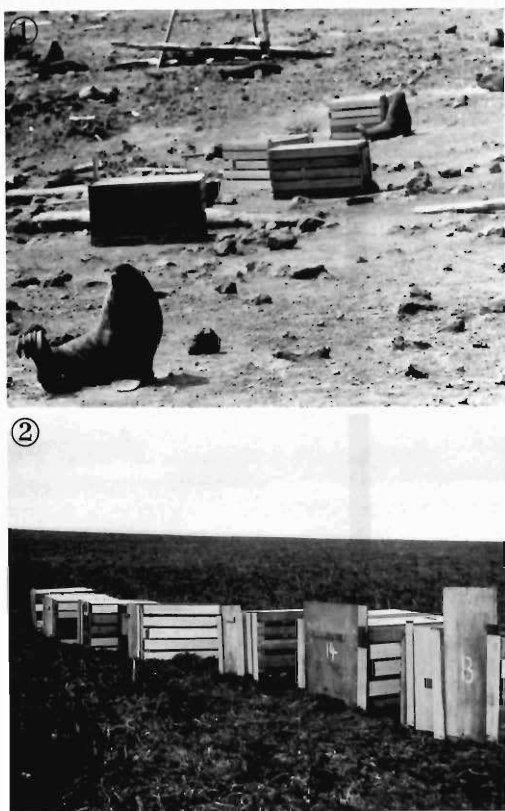
Discovery of the mode of transmission of *U. lucasi* will be discussed first. Before presenting details on this parasite, a few basic features of the life cycle of the host, the northern fur seal (Anonymous, 1977), are appropriate for an understanding of the intricacies of the hookworm life cycle.

Northern fur seals usually come on land only during the breeding season. They breed mainly on the Pribilof Islands, Alaska, in the Bering Sea.

Breeding bulls begin arriving in May and establish territories on rookeries for their harems. Pregnant cows start coming on land in June, and the main breeding season is from about mid-June through early August. Typically, cows stay on land about a week after first arriving. During this time, they give birth (within about 2 days), nurse their pups, and are rebred. The cows then go to sea to feed for several days, after which they return for a couple of days to nurse their pups. This routine is repeated during the nursing period, which lasts 3 or 4 mo.

When the author began investigations on the life cycle of *U. lucasi* in 1960, Dr. Olsen had already established several significant features (Olsen, 1958, 1959): (1) older seals did not have intestinal infections of adult hookworms; (2) pups had about 90% prevalence of adult hookworms; (3) pups, if they survived the effects of the parasite, “lost” intestinal infections at about 3 mo of age; (4) fourth stage larvae were found in very young pups born on rocks washed by the sea; (5) only 1 size or stage, i.e., L<sub>4</sub> or L<sub>5</sub> were found in pups; (6) no patent experimental infections could be produced in pups by administration of free-living L<sub>3</sub>; (7) hookworm larvae could not be recovered from lungs of pups born on rookeries; and (8) pups died from hookworm disease after being born on areas of rookeries: (a) sprayed with cresylic acid known to kill free-living L<sub>3</sub>, and (b) devoid of free-living L<sub>3</sub>, such as on rocks or soil where no overwintering of these larvae occurred. After all of these findings were evaluated, it was concluded that possibly the source of larvae for development to adult hookworms in pups was from prenatal infection.

The focus of initial research in 1960 by the author, working closely with Dr. Olsen, was to determine whether prenatal infection occurred.



Figures 1, 2. St. Paul Island, Alaska. Cages for containment of pregnant northern fur seal cows (not visible) in the experiment with 30 pregnant cows. 1. Cages on a rookery (Group I) with 2 bulls nearby. 2. Cages on "clean ground" (Groups II and III) where no free-living *L<sub>3</sub> Uncinaria lucasi* were present.

First, marked newborn pups, born on rookeries, were found to begin passing hookworm eggs in their feces at about 2 wk of age. Next, various tissues of 26 neonatal pups (19 taken by cesarean section, 6 stillborns, and 1 prematurely born), which never nursed, were examined, but no hookworms were found. Belly blubber only was examined from 12 additional fetal pups and it was also negative for larvae. Live pups ( $N = 12$ ), taken by cesarean section, were isolated in cages for periods ranging from 2 to 62 days (most for 10 days) and hookworms did not develop in them. Thus, there was no evidence of prenatal infection in the 50 pups examined. Because the natural infection rate of adult *U. lucasi* in pups born on rookeries was known to be about 90%, there appeared to be some other route of infection than prenatal.

In spite of the lack of evidence of prenatal

infection, a "mother factor" seemed to be involved because free-living *L<sub>3</sub>* would not mature in pups. An experiment was set up in 1961 to determine if infection of pups involved (1) the mother only, (2) the mother plus rookery, and/or (3) a specific time period postpartum. Thirty pregnant fur seal cows were collected, assigned to 3 groups (10 per group), and placed in individual cages. The protocol was: Group I—put on rookery soil (Fig. 1) and, on each of days 1–5 postpartum, take 2 pups to "clean ground" (an area inland, uninhabited by fur seals, where free-living *L<sub>3</sub>* were not present on soil or vegetation) for 1 day and then return them to their mothers; Group II—put on "clean ground" (Fig. 2) and, on each of days 1–5 postpartum, take 2 pups to rookery soil for 1 day and then return them to their mothers; and Group III—put on "clean ground" (Fig. 2) as controls and leave the pups with their mothers. This experiment provided the first evidence of the manner of transmission of *U. lucasi* to pups. The breakthrough occurred on 4 July 1961.

From this experiment with the 30 pregnant cows, some of the following aspects of the life cycle were derived: (1) 9 of 10 control pups (Group III) were positive for gastrointestinal infections of hookworms and (2) examination of young pups, 1 only 2 hr old, revealed hookworm larvae in milk in their stomachs. Subsequent research revealed that (1) parasitic *L<sub>3</sub>* were present in a mixture of mammary tissues, belly blubber, and milk from dead pregnant cows; (2) intestinal infections developed in pups, taken by cesarean section, after administration, by stomach tube, of parasitic *L<sub>3</sub>* derived from milk/belly tissues of pregnant cows; the prepatent period was about 2 wk; (3) hookworm larvae (1–135/cow) were recovered from milk samples from 7 of 8 pregnant cows; and (4) parasitic *L<sub>3</sub>* were also found in belly tissues of fur seal nonpregnant cows, bulls, bachelors, 2-yr-old males, yearlings, and pups, and Steller seal lion subadults. Thus, it was discovered that infections of adult *U. lucasi* in pups are derived from larvae passed through the mammary system of their mothers.

There were several indications that parasitic *L<sub>3</sub>* were present in milk of cows for only a short time postpartum: (1) only 1 size or stage of hookworms could be found in the gastrointestinal tract of pups; (2) postpartum cows ( $N = 8$ ) were milked in late summer and no larvae were found in their milk; (3) examination of milk from the stomachs of pups nursing cows that just returned from the

**Table 1.** Development of *Uncinaria lucasi* parasitic third stage larvae from various sources of belly tissues in intestines of experimentally exposed (via stomach tube) northern fur seal pups taken by cesarean section.

Source of larvae	No. of pups infected*/exposed
Northern fur seals	
Pregnant cows	21/23
Nonpregnant cows	0/2
Bulls	0/3
Bachelors	0/8
Pup†	0/1
Stellar sea lions	
Bachelors	0/2

\* Intestinal stages of *U. lucasi* recovered.

† From experimental exposure of pup taken by cesarean section to free-living *L*<sub>3</sub>.

sea revealed no larvae; any larvae present should have accumulated in the mammary system of the cows during the periods of several days at sea; (4) foster pups ( $N = 4$ ), taken by cesarean section and unfed, nursed 2 cows (their pups were removed soon after birth) in cages, and 3 of 4 became infected; also, 2 of these pups, at necropsy, 13 days after placement with foster mothers, harbored only adult hookworms; and (5) superinfections were attempted in 5 pups taken by cesarean section; 2 doses of parasitic *L*<sub>3</sub> from belly tissues/milk of pregnant cows were administered, the second dose 8–12 days after the initial dose. At necropsy, 2–4 days after the second exposure, 3 of the 5 pups had both immature (*L*<sub>4</sub>) and adult hookworms in their intestines, which indicated that pups were susceptible to more than 1 exposure to larvae. However, the reason naturally infected pups presented only 1 stage resulted from the short time postpartum, probably a few hours, that parasitic *L*<sub>3</sub> are in the milk.

Infectivity of parasitic *L*<sub>3</sub> from various sources of belly tissues was studied in fur seal pups taken by cesarean section (Table 1). Intestinal infections of hookworms developed in 21 of 23 pups given larvae from pregnant cows. However, intestinal infections did not develop in 16 pups given larvae from belly tissues of fur seal nonpregnant cows, bulls, bachelors, and a pup (experimentally infected with free-living *L*<sub>3</sub>), and Stellar sea lion bachelors.

Measurements were made of parasitic *L*<sub>3</sub> in belly tissues from various sources. Only total lengths are discussed in this paper. Most larvae from adult female fur seals were larger (802 and

939  $\mu$ m long for nonpregnant and pregnant cows, respectively) than those (641–732  $\mu$ m long) from a fur seal bull, a bachelor, 2-yr-old males, both sexes of yearlings and pups, and Stellar sea lion subadults. In belly blubber separated from mammary tissue of 2 pregnant cows, larvae were much shorter than those from a mixture of mammary tissue, belly blubber, and milk of other pregnant cows. The latter indicated that all larvae in tissues of pregnant cows are not depleted at pregnancy and all are not affected by the “growth factor.” Possibly, hormones or some other factor(s) cause parasitic *L*<sub>3</sub> in milk/belly tissues of pregnant cows to be larger and infectious. Adult hookworms can develop in pups whether born on rocky (Fig. 3) or sandy (Fig. 4) rookeries because the source of infection is parasitic *L*<sub>3</sub> in the milk.

Longevity and viability of parasitic *L*<sub>3</sub> in tissues of northern fur seal cows were evaluated in 3 situations by examining belly tissues of cows for larvae and/or feces of their pups for eggs (Table 2). This research indicated that parasitic *L*<sub>3</sub> live and are infective in cow tissues for at least 6 yr.

Research on free-living *U. lucasi* larvae indicated that there is development to *L*<sub>3</sub> within the egg. At room temperature, the time for development for the various stages was (1) *L*<sub>1</sub> by about 24 hr, (2) *L*<sub>2</sub> by about 40 hr, and (3) *L*<sub>3</sub> by about 60 hr. Hatching of *L*<sub>3</sub> occurred at about 100 hr. On rookeries, hatching does not occur until several months after deposition of eggs. Parasitic *L*<sub>3</sub>, passed in the milk, develop to *L*<sub>4</sub> about 24 hr after ingestion by pups. The final molt to *L*<sub>5</sub> occurs during the 4th and 5th days after infection.

The life cycle of *U. lucasi* can be summarized as follows (Lyons, 1963; Lyons and Keyes, 1984; Olsen, 1962; Olsen and Lyons, 1962, 1965):

#### A. Pups

1. Parasitic *L*<sub>3</sub> are acquired in the “first milk” of the mother and mature into adult hookworms in about 2 wk.
2. Adult female hookworms lay eggs that are passed in the feces of pups.
3. Adult hookworm infections are spontaneously eliminated after about 3 mo and are never present again.

#### B. Rookery soil

1. Free-living *L*<sub>3</sub> hatch from eggs in late summer.
2. Free-living *L*<sub>3</sub> enter seal tissues after oral/percutaneous infection.



Figures 3, 4. St. Paul Island, Alaska. Northern fur seals. 3. Cows and pups. Note cow in the center looking at her still wet, newborn pup. Whether pups are born on rocky (in this scene) or sandy terrain, they can develop infections of adult *Uncinaria lucasi* because the source of infective larvae is from milk stages of parasitic  $L_3$  stemming from free-living  $L_3$  previously acquired by their mothers. 4. Harems, consisting of bulls, cows, and pups. Hookworm disease is generally a greater problem in pups born on sandy rookeries (as in this scene) than on rocky rookeries. This is because seals tend to return to the area of birth, and, therefore, females inhabiting sandy rookeries have a greater chance of acquiring higher numbers of  $L_3$  in their tissues to pass in milk to their pups than do females on rocky rookeries.

C. Fur seals—all ages/both sexes

1. Parasitic  $L_3$  are found in belly and possibly other tissues.
2. Parasitic  $L_3$  remain in tissues except for parturient cows.

D. Parturient cows

1. Parasitic  $L_3$  pass in "first milk" to pups for a short time postpartum and these stages are the only ones that mature in pups.
2. Parasitic  $L_3$  in tissues live and are infective for several years.

Lucas (1899) believed that adult hookworms in northern fur seal pups that originated from hookworm larvae (free-living  $L_3$ ) located on fur around teats of cows and ingested while nursing. He was very close to being correct on the manner of infection of the pups.

After our initial publication of the life cycle of *U. lucasi*, 2 other reports of transmammary transmission of nematodes were found in the literature. They were on natural infections of *Trichinella spiralis* in humans (Salzer, 1916) and on *Ancylostoma caninum* and *Toxocara canis* in experimentally infected guinea pigs (Kotake, 1928, 1929). The potential significance of transmammary transmission in these reports was not recognized at the time of their publication.

The discovery of transmammary transmission of *U. lucasi* led to interest by several researchers to determine if this manner of infection occurred for other parasite species. Some of the earlier literature was, and still is, clouded because it was assumed in many instances that early-infected neonatal mammals could have been infected only by intrauterine infection.

### *Strongyloides westeri*

Research experience on the life cycle of *U. lucasi* would seem to have eased the unraveling of the life cycle of *S. westeri* in equids. However, it took 6 yr to discover the major way that foals are infected with this parasite. At the beginning (1963) of the concerted effort on research on the life cycle of *S. westeri*, knowledge on this parasite consisted mainly of the following (J. H. Drudge, pers. comm.; Russell, 1948; Todd et al., 1949): (1) prevalence of adult *S. westeri* in foals was about 90%, (2) most infected foals were passing eggs in their feces at about 2 wk of age, (3) foals were infected regardless of the time of year and place of birth, (4) indications were that infection of foals was at birth or soon after, (5) enteric infections were spontaneously eliminated by foals at a few months of age, and (6) older equids do not usually have adult enteric infections.

In the first major effort to investigate the life cycle of *S. westeri*, foals ( $N = 158$ ) were removed from their dams at a young age (0–11 days of age). Only 8 foals were positive for eggs in their feces during periodic examinations. Of the 8 infected foals, only 2 were less than 4 days old when removed from their dams. These observations seemed to contradict the theory of early infection of foals. However, the research also appeared to

**Table 2.** Longevity and infectivity of *Uncinaria lucasi* parasitic third stage larvae in tissues of northern fur seal cows.

Location	Cows		No. infected*/ examined	No. of pups infected†/ examined
	Time At sea	Captivity		
Bering Sea (Olsen and Lyons, 1965)	≥6 mo	—	20/27	—
Nanaimo, Canada (Lyons and Bigg, 1983)	—	4 yr	2/2‡	3/3
Seattle Aquarium (Lyons and Keyes, 1984)	—	6 yr	—§	2/2

\* Parasitic L<sub>3</sub> recovered from belly tissues at necropsy.

† *Uncinaria lucasi* eggs found in feces.

‡ Three gave birth, but only 2 examined.

§ Two gave birth, but neither examined.

substantiate the theory that prenatal infection did not occur.

Worm-free foals ( $N = 10$ ) were experimentally exposed to free-living L<sub>3</sub> *S. westeri*. All foals began passing eggs at 10–14 days postinfection. This prepatent period was similar to the age when eggs first appeared in the feces of naturally infected foals. This was more evidence that foals are infected at an early age, but the environmental source was not necessarily excluded in natural settings.

Placing pregnant mares ( $N = 7$ ) in separate isolated areas, devoid of free-living L<sub>3</sub>, provided the first strong indication that the dam was involved in infecting her foal. Foals born to 6 of the 7 mares began passing eggs at about 14 days of age. Other attempts were made to demonstrate the dams as a source of initial infections. Examination of mare tissue/excretions/secretions, including colostrum, revealed no *S. westeri* larvae. Additionally, tissues of fetuses and newborn foals were negative for *S. westeri* larvae. The latter observations indicated absence of prenatal infection.

At this point in the investigation, the source of the primary infection of foals was a mystery. It was evident that foals were definitely infected at or soon after birth. The question was: What could be the main source of infection if not prenatal, colostrum, or environmental?

Definite evidence that the mare does infect her foal was demonstrated in a simple experiment. A foal was removed from its dam at birth and placed in a cage where an environmental source of larvae was not possible. The mare was milked 5 times daily for 20 days. A portion of each co-

lostrum/milk sample was examined for larvae and the remainder fed to her foal. One larva was recovered from the milk at 11 days postpartum. The foal was passing eggs at 15 days of age. At 20 days of age, the foal was euthanatized and 8 adult *S. westeri* were found in its small intestine.

Subsequently, milk was collected from 82 mares and 32 were positive for *S. westeri* parasitic L<sub>3</sub>, first at 4 days and last at 47 days postpartum. Usually, a very low number of larvae were recovered from milk samples. Larvae were found in the mammary glands of 2 mares at necropsy. Periodicity of larvae in milk samples was found for 5 mares milked every 4 hr for 24-hr periods. The highest numbers of larvae (66–89%) were found in milk in the AM, mostly between midnight and 8 AM.

Parasitic L<sub>3</sub> from milk of mares were administered via stomach tube to worm-free foals ( $N = 7$ ) to determine if maturation occurred. The first eggs found in the feces of the foals appeared 8 or 9 days later in 6 foals and at 12 days for the other foal. This established, under experimental conditions, that parasitic L<sub>3</sub> in the milk were capable of maturing in foals.

There were several indications that parasitic L<sub>3</sub> of *S. westeri* require a shorter period for maturation than free-living L<sub>3</sub>. These were (1) foals, experimentally infected with parasitic L<sub>3</sub>, began passing eggs in feces 1 or 2 days earlier than foals infected with free-living L<sub>3</sub>; (2) larvae were not found in colostrum nor in milk until 4 days postpartum, even though eggs are found in feces of naturally infected foals by about 14 days of age; (3) some measurements for parasitic L<sub>3</sub> were greater than those for free-living L<sub>3</sub>; and (4) early



weaned foals, such as in the experiment where 158 foals were removed from their dams at 0–11 days of age, do not become infected because larvae are apparently not transmitted through the mammary system until a few days postpartum.

Although not present in colostrum, parasitic *L*<sub>3</sub> begin passing in the milk at a few days postpartum and, as previously mentioned, are capable of maturing quicker than free-living *L*<sub>3</sub>. Perhaps for *S. westeri*, as indicated for some other species of *Strongyloides* (Katz, 1969; Nolan and Katz, 1981), parasitic *L*<sub>3</sub> acquired through the milk do not undergo hepatopulmonary migration, which is apparently required by free-living *L*<sub>3</sub>.

The life cycle of *S. westeri* can be summarized as follows (Lyons et al., 1973, 1977):

#### A. Foals

1. Parasitic *L*<sub>3</sub> passing in the milk of dams are the probable major source of infective larvae that mature in foals.
2. Free-living *L*<sub>3</sub>, derived from eggs passed in foal feces, can infect orally and/or percutaneously and mature, but also can migrate to tissues; this stage probably is a minor source of infection resulting in adult worms in foals.
3. Adult *S. westeri* lay eggs that are first voided in the feces at about 2 wk of age.
4. Adult *S. westeri* usually are permanently eliminated when the foal is a few months of age.

#### B. Mares

1. Parasitic *L*<sub>3</sub> are transmitted to foals in milk, beginning a few days postpartum, continuing for several weeks.
2. Parasitic *L*<sub>3</sub> are stored in tissues and only mobilized during lactation.

### Summary of Vertical Transmission of Several Species of Nematodes

By the time that transmammary transmission of *S. westeri* was confirmed in 1969, it had been reported for a few other nematode species besides *U. lucasi*, including *Strongyloides ransomi* in swine (Moncol and Batte, 1966), *A. caninum* in dogs (Stone and Girardeau, 1966), and *T. canis* in dogs (Stone and Girardeau, 1967). Subsequently, several other nematode species were discovered to transmit larval stages through the mammary system of their hosts (Table 3).

Vertical transmission, both prenatal and trans-

mammary, is summarized for several nematode species (Table 3). Most of the references were derived from the excellent publication on this subject by Shoop (1991). The present summary is comprehensive regarding literature but may not include all nematode species with vertical transmission. The literature cited includes both natural and experimental infections. In some instances, experimental infections were in other than definitive hosts. For the table, question marks are placed in the "prenatal" or "transmammary" columns for some species because the exact type of transmission seems unclear.

Some of the research citations did not necessarily show that one or the other means of vertical transmission did not occur. For instance, a paper may relate that prenatal infection occurred, based on earlier than usual maturation. However, transmammary transmission, and possibly an environmental source, may not have been eliminated from consideration. It is believed that for each species of nematode, the references include the first, or at least an early, report of transmammary transmission; this is possibly not true for all species relative to prenatal infection.

Two lungworm species (*Dictyocaulus viviparus* and *Muellerius capillaris*) are not included in the table. This is because proof of vertical transmission is not apparent, according to Soulsby (1965) for *D. viviparus* and to Runge (1974) and Cabaret (1988) for *M. capillaris*.

Vertical transmission varies in its importance as a source of infective stages that develop to adult nematodes in neonatal mammals. For example, it is nonsignificant for filariids with microfilariae passing prenatally. However, it is highly significant for *U. lucasi* because parasitic *L*<sub>3</sub>, passed by transmammary transmission, are the only stages capable of maturation. Definite importance of prenatal/transmammary infection has not been determined for most nematode species for which vertical transmission has been reported.

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**Table 3. Summary of vertical transmission of nematodes.**

Nematodes	Transmission		References*
	Prenatal	Transmammary	
Rhabditoidea			
<i>Strongyloides</i> spp. ( <i>fulleborni</i> ?)	—	+	6
<i>S. papillosus</i>	—	+	7, 30, 35, 40, 53, 54
<i>S. ransomi</i>	+	+	11, 34, 48, 49
<i>S. ratti</i>	?	+	18, 19, 59, 60
<i>S. stercoralis</i>	—	+	15
<i>S. venezuelensis</i>	—	+	37
<i>S. westeri</i>	—	+	29, 31
Ascaridoidea			
<i>Ascaris lumbricoides</i>	+	—	8
<i>Toxascaris leonina</i>	—	+	47
<i>Toxocara canis</i>	+	+	13, 21, 51
<i>T. cati</i>	—	+	55
<i>T. pteropodis</i>	—	+	41
<i>T. vitulorum</i>	—	+	7, 56–58
Ancylostomatoidea			
<i>Ancylostoma caninum</i>	+	+	10, 12, 22, 50, 52
<i>A. tubaeforme</i>	—	+	46
<i>Gaigeria pachyscelis</i>	?	+	2
<i>Necator americanus</i>	+	—	1
<i>Uncinaria lucasi</i>	—	+	25–28, 38, 39
<i>U. stenocephala</i>	—	+	10
Metastrongyloidea			
<i>Protostrongylus stilesi</i>	+	—	17
Filarioidea			
<i>Brugia pahangi</i>	?	—	20
<i>Dipetalonema perstans</i>	?	—	61
<i>D. viteae</i>	+	—	16
<i>Dirofilaria immitis</i>	+	—	14, 24, 33
<i>D. repens</i>	+	—	32
<i>Loa loa</i>	?	—	61
<i>Onchocerca volvulus</i>	+	—	5
<i>Setaria cervi</i>	+	—	42
<i>Wuchereria bancrofti</i>	?	—	4, 9
Trichostrongyloidea			
<i>Dictyocaulus filaria</i>	+	—	36
<i>Nippostrongylus brasiliensis</i>	—	?	59
Strongyloidea			
<i>Stephanurus dentatus</i>	?	—	3
Trichuroidea			
<i>Trichinella spiralis</i>	+	+	23, 43–45

\* 1, Ackert and Payne (1923); 2, Ansari (1981); 3, Batte et al. (1966); 4, Bloomfield et al., (1978); 5, Brinkman et al. (1976); 6, Brown and Girardeau (1977); 7, Chauhan et al. (1974); 8, Chu et al. (1972); 9, Eberhard et al. (1993); 10, Enigk and Stoye (1967) (cited by Stoye, 1973); 11, Enigk et al. (1974); 12, Foster (1932); 13, Fülleborn (1921); 14, Galeb and Pourquier (1877) (cited by Beaver, 1970); 15, Haines et al. (1992); 16, Haque and Capron (1982); 17, Hibler et al. (1972); 18, Katz (1964); 19, Katz (1969); 20, Kimmig (1979); 21, Kotake (1928); 22, Kotake (1929); 23, Kuitunen-Ekbaum (1941); 24, Lewis (1879); 25, Lyons (1963); 26, Lyons and Olsen (1960); 27, Lyons and Olsen (1962a); 28, Lyons and Olsen (1962b); 29, Lyons et al. (1969); 30, Lyons et al. (1970); 31, Lyons et al. (1973); 32, Mantovani (1966); 33, Mantovani and Jackson (1966); 34, Moncol and Batte (1966); 35, Moncol and Grice (1974); 36, Neveu-Lemaire (1912) (cited by Soliman, 1953); 37, Nolan and Katz (1981); 38, Olsen and Lyons (1962); 39, Olsen and Lyons (1965); 40, Pfeiffer and Supperer (1969); 41, Prociv (1983); 42, Refuerzo (1952); 43, Roth (1935); 44, Roth (1936) (cited by Gould, 1945); 45, Salzer (1916); 46, Setasuban (1975); 47, Steffe (1983); 48, Stewart et al. (1969); 49, Stewart et al. (1976); 50, Stone and Girardeau (1966); 51, Stone and Girardeau (1967); 52, Stone et al. (1970); 53, Sukhapesna et al. (1975a); 54, Sukhapesna et al. (1975b); 55, Swerczek et al. (1971); 56, Tongson (1971); 57, Warren (1969); 58, Warren (1971); 59, Wilson et al. (1976); 60, Zamirdin and Wilson (1974); 61, Zanetti and Lambrecht (1948) (cited by Beaver, 1970).

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